TECHNICAL FEATURE

Subsea concept gets green light

As the offshore oil and gas industry continues its progression into deeper waters, the inadequacy of current field development systems is becoming increasingly evident. This is particularly apparent wherever long tie-backs are necessary and traditional seabed installations are used in conjunction with bespoke seabed manifolds. A new subsea processing system has been developed which could prove useful for marginal or stranded fields

Seabed processing close to the well head has long been identified as a potential means of overcoming the problems associated with slugging and hydrate formation. It also offers the opportunity of achieving large capital cost savings on fields that are difficult or uneconomic to develop by traditional means.

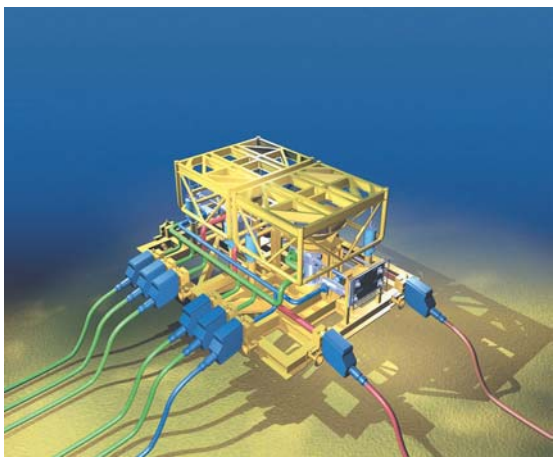
Unfortunately, for a variety of reasons, the industry has resisted adopting the technology needed to achieve these benefits. With the exception of Norsk Hydro and its pilot project on the Troll field, no operator has been willing to take the leap of faith necessary to introduce seabed processing technology.

The situation appears about to change now that Shell Technology Ventures has entered an agreement in which Alpha Thames will carry out a 15-month qualification programme with the assistance of the EP Projects division of Shell International Exploration and Production (SIEP). The programme is focused on qualifying Alpha Thames' products and technology for use in Shell Operating Units and field developments.

The agreement is a key milestone in a ten-year design and development programme during which the company's concept has been widely reviewed by the oil and gas industry.

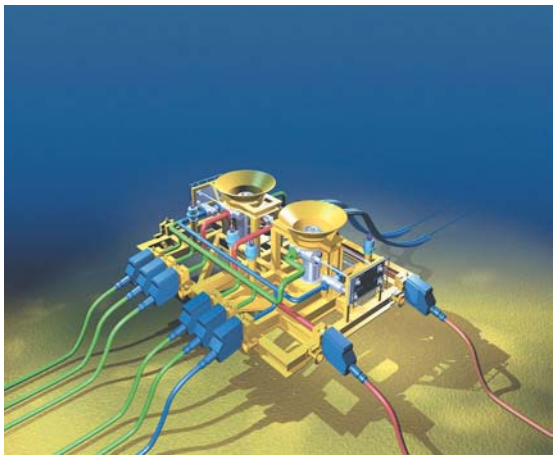
AlphaPrime

The AlphaPRIME system is designed to allow operators to re-adapt the system over time to match the reservoir's production characteristics, such as increased water cut. This is typically achieved by use of dual units – known as System-Modules – that can be individually reconfigured to optimise hydrocarbon throughput without shutting-off production. This design approach allows any new technology, including that of



The Flow-cap system module using conventional manifold components

A prototype AlphaPRIME system module



The Key-MAN unit would be the first component of the AlphaPRIME system to be installed on the seabed

third party manufacturers, to be incorporated within an existing system as and when it becomes available. This provides maximum system flexibility to the operator and ensures that equipment is provisioned and deployed only when it is needed, thereby reducing the initial capital expenditure budget.

A System-Module has already been built as a prototype with funding from Alpha Thames' Swedish parent group, SAAB and from the EU. The qualification programme will now include the manufacture and testing of electrical subsea connectors, valve actuators and the design of an AlphaCPU.

The programme is expected to last until late 2003 with the objective of achieving a standard that qualifies the entire system as being 'catalogue ready' for potential use offshore by Shell.

Commenting on the agreement, David Appleford, managing director of Alpha Thames said: 'We are obviously very pleased that Shell Technology Ventures has recognised the potential of the AlphaPRIME system and is supporting its development. In addition, the high level of interest and commitment being shown in the system by Shell does not preclude AlphaPRIME technology from becoming available to other oil companies. Work is already well in hand and we are now looking to recruit suitable personnel to expand our team.'

The AlphaPRIME approach to oilfield development centres on the deployment of a System-Modular installation known as an AlphaCPU which is located close to the wells on the seabed. Each installation consists of at least two identical operating System-Modules which are mounted on a 'KeyMAN' standard manifold and contain all of the pumping, processing and control equipment needed for the efficient operation of the field within each compact unit. If it becomes necessary to reconfigure a System-Module to accommodate changing field conditions, to introduce newly developed components or to overhaul any of its existing components, one entire System-Module is recovered leaving the other on the seabed to maintain production.

The new agreement forms part of Shell EP Projects' comprehensive global 'subsea-to-beach' initiative being implemented in close collaboration with Shell Technology Norway and a broad spectrum of vendors across the industry worldwide. Shell's Subsea to Beach programme was established two years ago and is aimed at creating a wide range of subsea processing technologies that can be packaged into systems and optimised for any application around the Shell Group.

Engineering designers at Alpha Thames have been studying the subject in considerable detail over the past ten years and have consequently established themselves at the forefront of this technology. Their most recent findings convinced them that the problems facing future field developments are not about the subsea and seabed processing equipment used, but rather about its configuration. Many of the items of equipment considered for seabed use have already proved their efficiency and reliability in land-based systems. Alpha Thames engineers now believe that such components are also appropriate for subsea use if they are assembled in an efficient configuration.

The main concerns of any field operator will be the reliability and availability of the seabed equipment and this has long been one of the reasons behind the industry's reluctance to adopt seabed processing. Alpha Thames has established that reliability can be significantly improved if the number of wet-mateable interfaces and connections between the components in the installation is kept to a minimum.

Any system containing rotating equipment and other control, power and processing components will, however, require periodic maintenance which means that it must be

easily retrieved from the seabed. Conventional thinking is to make such equipment items 'insert retrievable' whereby each component may be recovered for individual maintenance. This consequently demands numerous connections being made for each component in order to meet its requirements for process, power and control. In a deep sea environment all connections are potential points of weakness so each one will multiply the system's vulnerability to failure. This takes on an added significance when it is appreciated that the failure of just one small connection can immobilise an entire seabed installation.

Engineers at Alpha Thames identified this problem in 1983 and, since then, have been developing the use of System-Modules. David Appleford explained that: 'The basic principle behind the design is that it enables every piece of moving equipment on the seabed to be recovered leaving only pieces of *dumb* hardware such as flow lines and docking modules in place. Each System-Module is capable of containing process, pumping, controls, power distribution and, if required, metering equipment in one readily retrievable unit. Because almost all of the connections required for the functioning of the system are made in a dry workshop environment on the surface, the number of interfaces completed on the seabed is reduced to just two or three.'

This technique automatically eliminates a huge number of the potential points of failure that exist in *insert retrievable* technology. This reliability is further enhanced because each System-Module is fully integration tested and 'burnt-in' under factory conditions before it is deployed offshore. If any components should fail shortly after start-up they can be replaced in the workshop so that the early life failures often encountered with complex installations are avoided and optimum reliability is assured.

Each System-Module includes its own power/control pod which can also control the Xmas trees. This eliminates the need for each well to have its own subsea control module while also reducing the number of associated wet-mateable connections. The System-Module will form part of an AlphaPRIME system which has its own AlphaCPU that can become the control centre for development of the field.

PROAct electric valve actuator

REAct subsea electric failsafe actuator

A problem currently faced by field development engineers is the need to specify at the outset all seabed processing or booster pumping equipment that will be needed as reservoir conditions change during its life. Such over-specification can be avoided by using AlphaPRIME System-Modules as they can be easily removed for maintenance, reconfiguration or upgrading at any time during the field's life and without interrupting production.

This design feature allows inclusion of only the minimum equipment necessary for field start-up, thereby reducing CAPEX to only what is initially required. The cost of processing, pumping, metering or any other necessary equipment can be deferred until it is required. This flexibility also enables the latest and best equipment to be added to the system at any time during field life.

System-Modules can, for example, be initially configured simply to allow production throughput without any other equipment items being included. If water-break through occurs later, the System-Modules can be readily changed and fitted with produced water separation equipment and possibly injection/disposal pumps. At an even later date, if large volumes of gas are being produced, the System-Modules could be modified to include three-phase separation. Any additional pipelines required for the separated produced fluid could be laid and tied-in at first oil or later depending upon the field economics.

When the field first starts production a High Integrity Pressure Protection System (HIPPS) may be required to minimise export pipeline ratings and reduce costs. This can be included within the System-Module and removed for use elsewhere when the reservoir subsequently 'pressures out'. Similarly, because all but the foundation of an AlphaPRIME System-Modular installation can be quickly and easily retrieved and re-used at the end of field's life this benefit can be included in any costing exercise.

An AlphaPRIME system typically comprises a monopile foundation structure, a KeyMAN (docking-manifold), and a minimum of two identical System-Modules. All but the foundation has been designed to be readily retrievable. Weighing between 25 to 80t, according to configuration, the System-Modules can be installed and changed out within short weather windows using a relatively inexpensive vessel such as a DSV with ROV assistance. The autonomous System-Modules, which contain processing, pumping and metering equipment, in addition to a power/control pod, are easily removable by the disconnection of a standard multibore fluid connector and a power and controls connector. The KeyMAN would require the pipeline and flowline tie-ins to be disconnected to allow removal.

When Alpha Thames is brought in to work alongside the client company's engineers at the outset of a field's development, the system can be connected directly to the wells. In this application, the system would also act as a manifold facility as well as including any processing capability needed.

A typical AlphaPRIME developed field of 40 000b/d oil equivalent would use an AlphaCPU containing two System-Modules of 20 000b/d oil equivalent each. For larger fields, multiples of 20 000b/d oil equivalent System-Modules, or multiple AlphaCPUs, would be employed. This method proves

to be the most cost effective way of ensuring maximum production throughput whilst any one of the System-Modules is retrieved for upgrading or maintenance.

When two System-Modules are used, each Module would normally be sized for 60% of peak throughput, i.e. the system could handle 120% of peak flow. As the maximum peak throughput would only be for a short period of the overall field life, this would allow a minimum of 60% of peak flow to be maintained during System-Module change-out, without shutting-in any of the production wells. However, this percentage can be varied at the design stage to suit the client's requirements.

Maintenance

Another important benefit of the AlphaPRIME autonomous System-Modular design is that engineering maintenance of subsea equipment is now possible. This challenge has been avoided in the past simply by specifying equipment for the full field life. Where this is not possible, the equipment is expensively duplicated, tripled or specified as 'insert retrievable' with all the associated problems of connections reducing the system's reliability. Now, for the first time the planned maintenance of subsea installations is possible.

When an AlphaPRIME system is configured with subsea separation, numerous savings in both CAPEX and OPEX become possible. The cost benefits of separating water from the production fluid include:

- Reduced requirement for corrosion inhibitor
- Possible selection of carbon steel pipeline material
- Reduced hydrate prevention chemical requirement
- Reduced production pipeline diameter as a result of water removal.

Seabed separation increases the rate at which reserves can be recovered from the field due to reducing the wellhead backpressure. This increased recovery rate benefits the operator's cash flow and can drastically alter the economic viability of marginal fields. Independent studies have also shown that subsea separation can increase the reserves recovered by up to 75%. If this figure were applied to only a small number of fields, the additional earnings implications for an operator are substantial.

Although the ultimate goal of standardised field development layouts based on a virtual Internet on the seabed is achievable with today's known technology, it will be sometime before this is fully implemented. The first step towards this, however, has already begun as Shell and Alpha Thames pursue the qualification of key components needed by the all-electric system. Manufacture and testing is now under way for Alpha Thames' high voltage connector and its two designs for electrically operated valve actuators. The central control system is also being subjected to a detailed scrutiny but all other components needed will be industry standard equipment that is already well proven in the field.

Throughout the coming year Shell and Alpha Thames will be working to ensure that the AlphaPRIME system is ready for offshore use. When this happens it will open the door for a new approach to hydrocarbon recovery that will be available industry-wide where it can be expected to re-write the economics of offshore field development.